Mortality from Lower Respiratory Infection in Nursing Home Residents

A Pilot Prospective Community-Based Study

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BACKGROUND. Lower respiratory infections (LRI) are an important cause of morbidity, mortality, and hospitalization of nursing home residents, yet treatment recommendations have primarily been based on the minority who are hospitalized. We sought to prospectively evaluate risk factors for mortality from LRI in community nursing home residents.

METHODS. We studied residents of 10 central Missouri nursing homes (910 beds) from January 1994 to September 1994. Attending physicians authorized nurse evaluations of ill residents who showed symptoms of an LRI. Those residents who met the study definition of LRI received a more detailed assessment and follow ups at 30 and 90 days.

RESULTS. The 231 evaluations identified 141 LRIs in 121 individuals. Sixteen (11%) residents died within 30 days of evaluation. The most important univariate predictor of 30-day mortality was severe activities of daily living (ADL) dependency (relative risk = 8.8, 95% confidence interval, 2.55 - 30.1). Several other clinical and laboratory findings were also significant predictors. In multivariable logistic regression, ADL dependency, respiratory rate, and pneumonia on chest radiograph independently predicted mortality; the model showed good discriminating ability (c=.83).

CONCLUSIONS. For nursing home residents with LRI, ADL dependency is an important mortality predictor. Further research with a larger sample should lead to a useful prediction rule for outcome from nursing home-acquired LRI.

KEY WORDS. Respiratory tract infections; activities of daily living; risk factors; nursing homes. *(J Fam Pract 1998; 47:298-304)*

Lower respiratory infections—pneumonia, bronchitis, and tracheobronchitis—account for up to 12% of all hospitalizations of nursing home residents.[1] Contemporary studies show a lower respiratory infection (LRI) incidence of 540 to 943 per 1000 patient-years in nursing home residents, with 12% to 28% mortality from pneumonia or LRI.[2-8] Until recently, reviews of nursing home–acquired pneumonia uniformly advocated hospitalization or at least broad-spectrum parenteral antibiotics.[9-12] In addition to generating higher costs, hospitalizing nursing home residents may lead to consequences such as immobility, urinary catheterization, and pressure ulcers.[13,14] Identifying risk for poor outcomes from LRI would allow physicians to make more informed judgments about the best location for treatment.

To date five studies have examined outcomes from nursing home–acquired LRI or pneumonia.[2,5-8] Activities of daily living (ADL) dependency[2,5,6,8] and rapid respiratory rate[5,6] were the only outcome predictors identified in two or more studies. Four of these five studies were retrospective record reviews,[2,5-7] and all but one[6] involved only one or two facilities. Even the prospective study[8] did not involve standardized evaluation of residents at the time of illness. Variability in collection and recording of medical-record data is particularly problematic in nursing homes, which seriously limits our ability to draw firm conclusions from these studies. To test the methods for a larger study, we performed a prospective cohort study of outcomes of LRI in 10 central Missouri nursing homes. We hypothesized that ADL dependency would be a significant predictor of mortality from nursing home–acquired LRI.

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METHODS

Setting and Subject Identification

We studied residents of 10 central Missouri nursing homes with a total of 910 beds from January 1994 to September 1994. Subjects were identified from the patients of 77 of the 103 (75%) attending physicians who practiced at these facilities. These physicians authorized a protocol for physical evaluation and laboratory and radiologic studies for ill residents with systemic or respiratory symptoms raising the possibility of an LRI. Few of the nonparticipating physicians attended more than a handful of residents. The evaluations were conducted by project nurses, who called the facilities daily and visited them three to four times a week to assure identification of ill residents. (See supplemental Table 1 on the Internet at www.jfp.denver.co.us for full evaluation criteria.) Because evaluations were considered clinically appropriate under a physician-authorized protocol, we were able to substantially simplify the consent process to a simple acceptance or refusal rather than a formal written consent.

We excluded from evaluation residents with the following conditions: (1) age younger than 60 years; (2) AIDS; (3) a recent LRI, unless the resident was apparently well and had taken no antibiotics for at least 1 week; (4) a treatment limitation order prohibiting use of antibiotics; and (5) terminal illness with a life expectancy of less than 1 month. We classified each LRI as either "pneumonia" or "other LRI," according to a consensus-development conference surveillance definition for long-term care facilities (Table 1).[15] All questionable cases (eg, minimal respiratory symptoms and fever in a patient with congestive heart failure and urinary tract infection) were reviewed by two physician investigators (D.R.M. and S.C.Z.).

Data Collection and Measures

For each probable LRI, project nurses further evaluated the resident with the assessment instrument from the Minimum Data Set for Resident Assessment and Care Screening (MDS).[16] The MDS is a federally mandated instrument required nationwide in nursing homes with any Medicare or Medicaid beds. When used by trained nurses, it has shown excellent reliability.[17] Project nurses reassessed residents with LRI after 30 days and identified any deaths within 90 days. We chose 30 and 90 days to be consistent with the work of the Pneumonia Patient Outcomes Research Team (personal communication, Wishwa Kapoor, MD, MPH).

All clinical information was recorded on standardized forms, placed in the medical record, and subsequently abstracted by a research assistant. The assistant also abstracted other data from hospital and nursing home records, such as antibiotic therapy.

From MDS information, we calculated two ADL scales and a cognitive measure. We identified and

TABLE 1

Study Definition of Lower Respiratory Infection

To be defined as **pneumonia,** a lower respiratory infection (LRI) must meet *both* of the following criteria:
- Interpretation of a chest radiograph as demonstrating pneumonia, probable pneumonia, or the presence of an infiltrate. If a previous radiograph exists for comparison, the infiltrate should be new.
- The resident must have at least two of the signs and symptoms described under "other LRI."

Comment. Noninfectious causes of symptoms must be ruled out. In particular, congestive heart failure may produce symptoms and signs similar to those of respiratory infections.

To be defined as **other LRI** (bronchitis, tracheobronchitis), at least three of the following signs and symptoms must be present:
- New or increased cough
- New or increased sputum production
- Fever (≥38 °C)
- Pleuritic chest pain
- New or increased physical findings on chest examination (rales, rhonchi, wheezes, bronchial breathing)
- One of the following indications of change in status or breathing difficulty: new or increased shortness of breath *or* respiratory rate >25 *or* worsening mental or functional status (significant deterioration in the ability to carry out the activities of daily living or in cognitive status)

Comment. This diagnosis can be made only if no chest film was obtained or if a radiograph failed to confirm the presence of pneumonia. In the presence of chronic obstructive pulmonary disease or coronary heart failure, the definition was modified to also require either a temperature of ≥38 °C or a clear-cut pneumonic infiltrate.

Note: Our definitions are based on the statement of a consensus-development conference concerning infection-surveillance in long-term care facilities.[15] Used with permission. We modified the definition to explicitly exclude residents with chronic obstructive pulmonary disease or coronary heart failure who lacked either a fever or an infiltrate on chest radiograph to avoid including exacerbations of those conditions as an LRI.

summed the number of dependencies using Katz's index of ADL.[18] We also used numerical weights developed by Finch, Kane, and Philp[19] to convert responses on 11 MDS items to a magnitude estimation ADL scale. Values vary from 0 (independent on all these items) to 5431 for a fully dependent resident. Cognitive status was measured with the MDS-based cognitive performance scale (CPS), a reliable and valid scale ranging from 0 to 6, with higher values indicating increasing cognitive impairment.[20,21]

We assessed nutritional status with use of the body mass index (weight in kilograms divided by height in meters squared) and by obtaining serum albumin and cholesterol as part of a chemistry panel. We assessed renal function with blood urea nitrogen (BUN), serum creatinine, and an estimated creatinine clearance from age, weight, sex, and serum creatinine by the method of Cockcroft and Gault.[22]

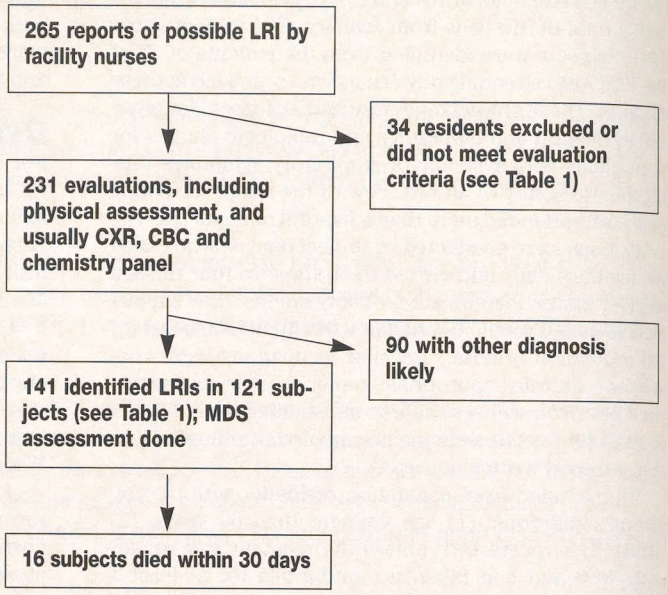
Analysis

We included in our analysis all distinct LRI episodes, including multiple episodes in the same person. We defined initial treatment as having occurred in the nursing home if antibiotics were started there or, in the absence of antibiotics, if hospital transfer had not occurred within 24 hours after evaluation. In some analyses, we divided antibiotics into three groups: oral antibiotics except fluoroquinolones, fluoroquinolones (in this study, ofloxacin and ciprofloxacin only), and parenteral antibiotics. Fluoroquinolones have been considered a possible substitute for some parenteral regimens in nursing home–acquired LRI.[23,24]

Data were analyzed with SAS statistical software.[25] We initially calculated unadjusted relative risks and 95% confidence intervals for 30-day mortality. In selected instances we used the Mantel-Haenszel method to control for confounding by a single variable.[26] We then developed forward and backward stepwise multivariable logistic regression models to test whether variables were independently predictive. To create more stable models, we adjusted for missing data. We excluded variables with more than 10% missing data (eg, serum chemistries). Otherwise, for binary variables we arbitrarily assigned the low-risk category (usually approximately 80% of the sample). In all cases this imputation decreased the strength of associations rather than creating extraneous associations.

FIGURE 1

Subject Identification and Evaluation



LRI denotes lower respiratory infection; CXR, chest radiograph; CBC, complete blood count; MDS, Minimum Data Set for Resident Assesment and Care Screening.

RESULTS

Figure 1 describes subject identification and evaluation. The 265 reports of possible LRI occurred among 210 residents with a mean age of 85.6 (standard deviation 8.3, range 63 to 103). The 231 resulting evaluations identified 141 LRIs in 121 individuals. Twelve residents had two episodes, and four residents had three. In two additional instances, subjects technically met the study definition for LRI but were excluded because congestive heart failure and a urinary tract infection fully explained their symptoms without invoking a third illness.

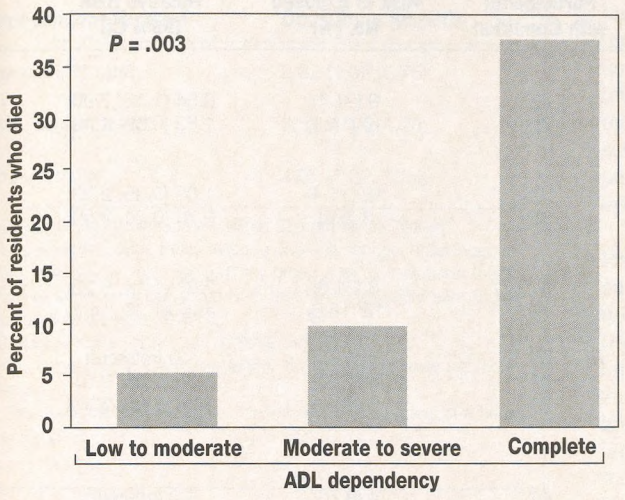
Sixteen residents (11.4%) died within 30 days of illness onset, and 25 (18.1%) within 90 days. Forty-two LRIs (30%) were classified as pneumonia. Thirty-day pneumonia mortality was 21.4%, and pneumonia accounted for 9 of the 16 deaths. While 19 residents received initial treatment in the hospital, 43 residents (30%) were hospitalized within 30 days of illness identification.

The magnitude estimation ADL scale was strongly related to mortality (Figure 2). Accounting for half the deaths, the 21 individuals fully dependent on the magnitude estimation scale were 8.8 times (95% confidence interval [CI], 2.55 - 30.1) more likely to die than those least dependent. Being fully dependent according to the Katz scale also predicted death (Table 2); however, half of all residents with LRI were identified as fully dependent by the Katz scale, so it was less useful in discriminating between those likely to survive and those likely to die.

In addition to ADL measures, Table 2 shows 30-day mortality relative risks and 95% confidence intervals for a variety of resident characteristics. A number of vital sign abnormalities, use of an indwelling urinary catheter, and

FIGURE 2

Thirty-day mortality from lower respiratory infection in nursing home residents, grouped by ME ADL scale status.



ME ADL denotes magnitude estimation activities of daily living.

several laboratory abnormalities strongly predicted dying. The only comorbid condition that appeared important was the presence of chronic obstructive pulmonary disease (relative risk [RR] = 2.4; 95% CI, 0.96 - 6.10).

Residents received a wide variety of antibiotics, with 23 different agents included in initial therapy. Eleven persons were not treated with antibiotics. None died. However, it is important to note that we excluded individuals with explicit no-treatment orders. Additionally, the 49 residents initially treated at the nursing home with amoxicillin, ampicillin, trimethoprim-sulfamethoxazole, a tetracycline, or a macrolide did strikingly well, with no deaths. Most hospital regimens included a parenteral second- or third-generation cephalosporin. (Supplemental Table 2 on the *Journal*'s Web site at www.jfp.denver.co.us provides more detailed antibiotic data.)

Initial hospitalization was associated with higher mortality (RR = 3.2; 95% CI, 1.22 - 8.30). Also, those residents initially treated with fluoroquinolones (RR = 3.9; 95% CI, 1.16 - 12.9) and those initially treated with parenteral antibiotics (RR = 3.7; 95% CI, 1.27 - 10.8) had higher mortality risks than those treated with other oral antibiotics. However, these relationships could be confounded by more seriously ill residents being given more aggressive treatment. Using the Mantel-Haenszel method to adjust for confounding by ADL status, risks for fluoroquinolones (adjusted RR = 2.8; 95% CI, 0.89 - 9.10) and parenteral antibiotics (adjusted RR = 3.0; 95% CI, 1.12 - 8.24) were somewhat attenuated. This indicates that these residents' poorer outcomes are related, at least in part, to their risk status rather than their treatment.

Results of multivariable logistic regression are shown in Table 3. The magnitude estimation ADL variable was a highly significant predictor. The presence of pneumonia and the subject's respiratory rate (<21, 21 to 30, and >30) were the other two significant variables. Based on the Hosmer-Lemeshow goodness-of-fit statistic and the *c* statistic (equal to the area under the receiver operating characteristic curve), the model had acceptable goodness of fit and reasonably good predictive value. The reported model is undoubtedly limited by the small number of outcome events (deaths), which also prevented its use to control for confounding in comparing initial treatments.

DISCUSSION

To our knowledge, our data represent the first prospective findings concerning predictors of mortality from LRI in community nursing home residents. The results show the importance of ADL status as an outcome predictor. Our findings also demonstrate the feasibility of developing an effective predictive model with a larger study; this would inform treatment decisions for nursing home residents, such as choice of antibiotics and whether to hospitalize. For example, a low-risk resident might appropriately be treated with oral antibiotic therapy in the nursing home.

The Pneumonia Patient Outcomes Research Team (Pneumonia PORT) has provided a reasonably concise prediction rule for mortality risk from community-acquired pneumonia.[27] However, only a small proportion of these subjects were nursing home residents, and residents treated exclusively at the nursing home were not included. The Pneumonia PORT algorithm includes rapid respiratory rate but not ADL status. Several comorbid conditions are also important in this model. In contrast, in our sample comorbid conditions were poor predictors even in univariate analysis. The importance of ADL and the unimportance of comorbid conditions may reflect the high level of disability in nursing homes, compared with disability in the community.[28] Our sample of nursing home residents with LRI is even more severely impaired. For example, 80% of residents in our sample had five or six Katz ADL dependencies.

ADL dependency[2,5,6,8] and rapid respiratory rate[5,6] have repeatedly appeared as important predictors in other nursing home studies, and our results have confirmed their importance. Other previously identified predictors were not sustained by our results, including age,[2] body mass index,[2] dementia,[5] orders not to hospitalize,[5] and rapid pulse.[6] Low or high pulse rate, low systolic blood pressure, and temperature above 38.2 °C were significant in our univariate analysis. Some of these may be discovered to be important independent predictors with a larger data set.

TABLE 2

Mortality from Lower Respiratory Infection in Nursing Home Residents, by Potential Predictors

Predictor	30-day Mortality			
	No. of Missing Values*	No. of Participants with Condition	Risk of Exposed No. (%)	Relative Risk (95% CI)
Diagnosis				
Probable pneumonia	14	42	9 (21.4)	3.04 (1.16, 7.96)
Possible pneumonia	14	70	10 (14.3)	1.63 (0.59, 4.49)
Demographics				
Sex, Female	0	105	12 (11.4)	1.03 (0.35, 2.99)
Age, >91 years	0	32	3 (9.4)	0.79 (0.24, 2.59)
ADL Status				
Resident bedfast	0	37	8 (21.6)	2.81 (1.14, 6.95)
Katz ADL: 6 dependencies	2	70	13 (18.6)	4.27 (1.27, 14.3)
Magnitude estimation ADL				
≤4500	0	69	3 (4.35)	1.0 (referent)
4501 to 5430		51	5 (9.80)	2.26 (0.56, 9.01)
5431		21	8 (38.1)	8.76 (2.55, 30.1)
Cognitive Performance Scale Status (0 to 6 scale)†	8			
0 to 2		41	4 (9.76)	1.0 (referent)
3 to 5		57	3 (5.26)	0.54 (0.13, 2.28)
6		35	8 (22.9)	2.34 (0.77, 7.12)
Vital Signs (at nurse evaluation)				
Systolic blood pressure ≤110	1	32	7 (21.9)	2.62 (1.06, 6.49)
Diastolic blood pressure ≤ 60	0	44	6 (13.6)	1.32 (0.51, 3.41)
Temperature ≥38.2 °C	0	33	7 (21.2)	2.54 (1.03, 6.31)
Pulse, beats per minute				
70 to 99	0	94	5 (5.32)	1.0 (referent)
≤69		17	4 (23.5)	4.42 (1.32, 14.8)
≥100		30	7 (23.3)	4.39 (1.50, 12.8)
Respiratory rate > 30	0	41	8 (19.5)	2.44 (0.98, 6.06)
Conditions				
Catheter in use	0	20	6 (30.0)	3.63 (1.48, 8.88)
Decubitus ulcer	0	22	5 (22.7)	2.46 (0.95, 6.38)
Body mass index <17.5	13	27	2 (7.41)	0.83 (0.19, 3.62)
Lab Findings				
Albumin <3.0	39	27	6 (22.2)	5.56 (1.49, 20.7)
Potassium >5.0	33	9	4 (44.4)	5.50 (2.05, 14.8)
White blood cells ≥15,000	10	33	7 (21.2)	3.46 (1.25, 9.58)
Lymphocytes ≤800	12	28	6 (21.4)	3.09 (1.13, 8.46)
Cholesterol <140	40	21	5 (23.8)	4.76 (1.40, 16.2)
Creatinine clearance < 25	38	27	6 (22.2)	5.63 (1.51, 21.0)
Blood urea nitrogen ≥30	19	38	9 (23.7)	4.97 (1.63, 15.1)
Comorbid Conditions				
Coronary heart disease	0	40	5 (12.5)	1.15 (0.43, 3.09)
Chronic obstructive pulmonary disease	0	28	6 (21.4)	2.42 (0.96, 6.10)
Coronary heart failure	0	31	3 (9.68)	0.82 (0.25, 2.69)
Cerebrovascular disease	0	34	4 (11.8)	1.05 (0.36, 3.04)
Cancer	0	14	0 (0.0)	‡
Diabetes mellitus	0	19	2 (10.5)	0.92 (0.23, 3.72)
Hypertension	0	46	3 (6.52)	0.48 (0.14, 1.59)

ADL denotes activities of daily living; CI, confidence interval.

* Based on 141 episodes in 121 residents.

† Higher scores indicate poorer cognitive function.

‡ No mortality in exposed group prevents computation of confidence intervals.

TABLE 3

Logistic Regression of 30-Day Mortality in Nursing Home Residents with Lower Respiratory Infections (N=141)

Independent Variable	Odds Ratio (95% CI)
Respiratory rate*	2.62 (1.02, 6.75)
ADL dependency†	2.51 (1.54, 4.08)
Pneumonia‡	4.05 (1.22, 13.4)

ADL denotes activities of daily living; CI, confidence interval.
Note: Reported odds ratios reflect a one-unit change in the independent variables (ie, ADL dependency group 2 vs 1). *c*-statistic=0.829. Hosmer-Lemeshow goodness-of-fit test P=.18 (nonsignificant finding indicates acceptable model fit).
*Respiratory rate: <21=1; 21 to 30=2; >30=3.
†ADL dependency: low to moderate=1, moderate to severe=2, complete=4.
‡ The presence of pneumonia determined by the reading of a chest radiograph.

Presence of a urinary catheter was also associated with mortality in our univariate analysis. Catheter use could be a proxy for severe disability, or it could predispose to mortality from urosepsis, which could be confused with LRI under some circumstances. We believe the first interpretation is more likely for two reasons. First, controlling for ADL status, pneumonia, and respiratory rate with logistic regression, catheter use does not remain a significant predictor. Second, we excluded from evaluation febrile catheterized patients, unless they also exhibited respiratory symptoms, and we reviewed and excluded all those with urinary tract infections who appeared likely not to have an LRI. These precautions make it less likely that we were misclassifying residents with urosepsis as having an LRI.

Not surprisingly, low albumin and very low cholesterol—both potential indicators of malnutrition—are also very strong predictors of mortality; however, body mass index, another useful nutritional indicator, was not significant. We did not consider albumin and cholesterol in logistic regression because of the excessive number of missing values, but they may be important independent predictors in a larger study.

The findings of increased mortality with high white blood count and low lymphocyte counts are clinically sensible though uncommon in other studies. Two studies of hospitalized elderly patients with pneumonia did identify leukocytosis as a risk factor for mortality.[29,30] The Pneumonia PORT prediction rule, however, does not include either.[27] Low lymphocyte count is a marker of impaired immune function and would be expected to predispose to poor outcome. Nonetheless, we have not previously seen it reported in other studies of pneumonia or LRI outcomes.

LIMITATIONS

The main limitation of this study is its size. Larger studies and studies in other settings are needed. Small numbers particularly constrained our logistic regression modeling. The inclusion of more than three variables usually led to very large odds ratios and confidence intervals that suggested overfitting: a situation where the model too closely matches the peculiarities of data in the sample.[31,32] Overfitting tends to occur with multiple independent variables and a small number of outcome events.

Several other objections could be raised. Potentially, our recruitment methods could have created an unrepresentative sample. Although we were unable to evaluate some residents (primarily because their physicians had not agreed to our protocol), we have no evidence to suggest any systematic differences between patients of participating and nonparticipating physicians. We also had substantial missing laboratory data, which prevented us from using it in multivariable analyses. Finally, some may object to our including multiple episodes for the same individual as a violation of statistical independence. Where death is the outcome of interest, Rothman[33] has argued that it is appropriate to include multiple illness occurrences in the same individual. Clinically, a series of LRI episodes often occurs before a final terminal episode.

A particular strength is our broad sample of residents assessed and our approach to solving the difficult problems of informed consent in nursing home research.[34-37] This study represents an unusual example of practice-based research in the nursing home setting. Previous studies often used special populations that were not generalizable to community nursing home residents. Our findings support the importance of not relying on these biased populations for information about the outcomes of community nursing home residents.

CONCLUSIONS

This work can provide the basis for developing a prediction rule for the outcomes of LRI in nursing home residents. This would aid physicians in treatment decisions and enable researchers and regulators to consider issues, such as quality of care, that depend on being able to account for underlying severity of illness. With sufficient numbers, we should be able to develop a multivariable risk index to estimate illness severity.

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